alis), cloud bent (*A. nebulosa*), harestail (*Lagurus ovatus*), and the quaking grasses (*Briza maxima, B. minor,* and *B. media*).

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BAMBOOS FOR FARM AND HOME

F. A. McCLURE

THE BAMBOOS are set off from the more familiar grasses by certain technical characters, such as the woody stems and the petiolate, or stalked, leaf blades. They comprise a highly varied array of plants that range in size and habit from tiny dwarfs a few inches high to long and slender climbers and giants a foot in diameter and more than 100 feet tall. Among them are individual kinds with properties that suit them, in aggregate, to a thousand functions. Many of the uses, although of basic importance in the areas where industry remains largely in the handicraft stage, are looked upon in this mechanized world only as curiosities. Other uses have come closer to our everyday lives than most of us know.

The most successful of Thomas A. Edison's early incandescent electric lamps had for its light-giving element a carbonized filament of bamboo—a slender, wirelike element made from a single fibro-vasular bundle from an internode of a bamboo culm, or stem. Bamboo fibers were still used in carbon-filament lamps for special purposes as late as 1910.

Apparently—we are not sure—Edison used fibers from a species of bamboo growing wild in the jungle at an elevation of about 5,000 feet on the slopes of Volcan Chiriquí, Panama. I have collected botanical specimens and fibers from this bamboo, which is said by local witnesses to have been the source of some of Edison's experimental material. It is *Chusquea pittieri* Hackel, a plant that appears to the casual observer to be of little interest or technical promise.

There have been many changes since the carbon-filament lamp revolutionized illumination, but bamboo now promises to offer to the technical world another fundamental raw material, cellulose. That the bulk of China's vast paper requirements has been supplied, for hundreds of years, by hand-dipped bamboo pulp is common knowledge. It may be news to many, however, that paper is already being made by machine, on a commercial scale, from bamboo pulp in Trinidad, Siam, Burma, India, and France, as well as in China. The Forest Research Institute at Dehra Dun, India, publishes its annual reports on machine-made bamboo paper, which seems to me to be the equal of the best book paper made from wood pulp.

The promise of bamboo is great. This is in terms of yearly per-acre production of cellulose and of possible increase of digester capacity.

Estimates based on carefully documented records of the United States Forest Service indicate that plantations of slash pine managed on a 35-year rotation gave, at a time when most of the trees were under 20 years of age, an average annual yield of 1.13 tons of oven-dry, sulphate, kraft pulp per acre. *Bambusa vulgaris,* on the other hand, according to records of the Trinidad Paper Pulp Co., Ltd., mentioned by the general manager, C. T. B. Ezard, in an interview, has produced more than 4 tons of pure, dry, cellulose pulp a year on a 3-year cutting cycle, at St. Augustine, Trinidad. On a 4-year cutting cycle it produced up to 4.5 tons.

As for digester capacity, the capacity of a given digester, in terms of yield

per charge, has been increased as much as 20 percent by using some species of bamboo instead of southern pine. This increase, with the use of bamboo, is due to the greater density and better loading properties of bamboo chips.

Only by actual experiment can we find whether existing wild stands of bamboo will meet the ultimate need. In any case, we cannot afford to ignore what has happened to our wild stands of pulp-producing forest trees. The great reservoirs of one species after another have been depleted to an alarming extent by the axe of the pulpwood gatherer, and it remains to be seen whether scientific management of the remnants will succeed in raising the production of pulpwood to levels at which our skyrocketing consumption of pulp can be supplied.

The rapidly mounting requirements of the rayon industry are now added to those of the paper industry. The combined consumption of pulpwood by the paper and rayon industries of the United States increased more than 60 percent in the past decade, according to statistics supplied by the Forest Service—from 10,349,000 cords in 1937 to 17,816,000 cords in 1946.

For the rayon industry, also, certain bamboos have been found well suited by virtue of superior technical properties, including a high alpha-cellulose content. That the use of bamboo for cellulose is no longer in the experimental stage is suggested by the fact, as we find in *Fibres,* for March 1947, that a company has been organized in Travancore, India, for the commercial production of rayon from bamboo. Such use of bamboo may well be extended as the demand for rayon continues. *Forest Resources of Chile,* issued by the Forest Service, reported that "World production of rayon has been going up rapidly, from about 20 million pounds in 1912 to almost 2,000 million pounds in 1938."

Building upon the fundamental research carried out by William Raitt through many years of patient labor, our great paper research laboratories have been refining the methods and perfecting the techniques of using bamboo in the making of paper. Now it is possible on a commercial basis to make any desired quality of paper from a large number of different bamboos. Among the principal remaining problems are to find the best, most productive, and most easily harvested bamboos and to mechanize the processes of cutting and preparing them for the mill.

During the recent war, unseasoned, home-grown, bamboo culms sold at wholesale for as much as 25 cents a running foot. The acute shortage of bamboos suitable for our strategic needs, which developed soon after our supply from the Far East was cut off, emphasized the importance of establishing numerous plantings of superior bamboos in the Western Hemisphere. From these plantings, supplies adequate for our needs might be drawn should a similar emergency arise.

Through its program of technical collaboration with Latin American countries, the Office of Foreign Agricultural Relations of the Department of Agriculture is fostering the development of such a reservoir of superior bamboo material.

As a part of the program of its Tropical Forest Experiment Station at Rio Piedras, P. R., the Forest Service is conducting extensive experimental plantings of several species of bamboo. Because of their excellent soil-binding properties and heavy mulch production, bamboo plantings are particularly appropriate for trial on waste-land too steep for cultivation. In the experiments at Rio Piedras, bamboos are being tested as a possible crop for such lands.

The Federal Agricultural Experiment Station at Mayaguez, P. R., experimenting with bamboos introduced from abroad, has brought to light a great deal of basic information concerning methods of propagation, seasoning, utilization, protection against the attacks of wood-eating insects, and so on.

The Forest Products Laboratory at Madison, Wis., has carried out preliminary studies on several species of bamboo. The studies include tests of strength, gluing tests, and impregnation for the modification of the physical properties of the culms and for protecting them against insects and fungi.

A large collection of living bamboos from abroad has been built up at the Barbour Lathrop Plant Introduction Garden, near Savannah, Ga., and at the Coconut Grove Garden, near Miami, Fla., by the Department of Agriculture through its Division of Plant Exploration and Introduction.

Uses on the Farm

Besides the commercial importance of products obtained from bamboo, its use as a supplementary crop and source of material for farm and home use is interesting. The development of bamboo for such uses has only just begun.

Propagation material of bamboos of excellent technical properties is available in the United States. They can be grown in a large part of the United States. Groves of bamboo on the farm can be useful as chicken runs and bird refuges. They can also supply edible shoots, supplemental winter forage for livestock, and poles for a hundred other uses: Tree props, poles for harvesting nuts and Spanish moss, fishing poles, fish-net handles, chicken fences, garden stakes, lining-out poles for fence building, and for staking off lands in plowing—to name only a few.

Once a grove is established, boys and girls can soon learn to supplement their incomes by selling poles in town for use in window displays, for interior decoration, vaulting poles, javelins, musical instruments, handles for insect-collecting nets, and material for basketry and other manual training and handicraft needs.

On the basis of documented material, government and private agencies are making tests and analyses of introduced bamboos, to ascertain the relative excellence of individual kinds for specific purposes. On the basis of our present knowledge, certain species from India of the genus *Ochlandra,* not yet introduced, appear to be better suited for the production of cellulose pulp for paper and rayon than anything now available in the Western Hemisphere.

All the continents except Europe have bamboos in their native flora. It is estimated that the total number of distinct kinds of bamboo that have been described is between 600 and 700. These comprise about 60 genera. Nine genera, with about 200 species, have been described from the Western Hemisphere.

Of these nine American genera, only one, *Arundinaria,* has been found outside this Hemisphere—in Asia and Africa. The known native bamboo flora of the United States comprises two species and several varieties of the genus *Arundinaria. A. gigantea,* the Giant Southern Cane, occurs in southern Ohio, Indiana, Illinois, Missouri, Oklahoma, and other States to the south; the switch cane (*A. tecta*) is confined to the Atlantic and Gulf coastal region from Maryland southward. Once more abundant and more utilized than now, our native canes have gradually been eliminated by the plow from most of the fertile valley lands where they flourished in extensive groves, or canebrakes, which served as refuges for birds, bear, and deer, and provided winter protection and forage for domestic animals.

Other genera of the Western Hemisphere are:

Arthrostylidium (mostly climbers);

Aulonemia (the thin-walled culms are often used for weaving, thatch, and shepherds' pipes and the leaves for forage);

Chusquea (mostly climbers with solid, largely pithy, stems used locally in basketry and in house construction; and with abundant foliage which often furnishes grazing for cattle and green fodder for guinea pigs in the highlands of Ecuador and Peru);

Elytrostachys (the type species, with

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climbing, thin-walled culms; it flowers frequently and bears abundant, edible grains);

Glaziophyton (known by a single species whose small, smooth, and thin-walled culms with chambered pith are branched only near the tip);

Guadua (closely related to the Asian genus *Bambusa;* mostly thorny species, the giant, 80–90 foot culms of *G. angustifolia* constitute the principal building material in parts of Colombia and Ecuador);

Merostachys (chiefly Brazilian; all the known species have thin-walled culms); and two, *Athroostachys* and *Brasilocalamus,* or *Rettbergia,* (of which little is known).

The natural distribution of bamboos in the Western Hemisphere extends from the southern part of the United States southward to Argentina and Chile, and from sea level to elevations of more than 12,000 feet in the tropics. Gaps occur principally in relatively arid regions or in places where agriculture has destroyed the natural forest cover. Species of *Arundinaria* and *Chusquea* are the most cold-resistant of the western bamboos; the former extends farthest north and the latter farthest south and highest above sea level.

It is well known that in parts of the Far East the utilization of various species of bamboo has been highly developed and greatly diversified. Perhaps less familiar are the facts relating to the importance of bamboo in the local economies of the countries to the south of us, where species of *Guadua, Chusquea, Arthrostylidium, Autonemia,* and *Merostachys* are found. These, according to their natural occurrence and technical properties, supply the principal or preferred material for houses, fences, bridges, basketry, and so on. Many of the Old World species introduced into the Western Hemisphere provide superior material for these and other purposes.

During the past 50 years or so, many bamboos have been introduced into the United States, principally from China, Japan, Java, and India. The introduction and subsequent trial of these bamboos have been the work of many individuals, and of private and governmental agencies. At Mayaguez, major attention has been given the tropical species. The agronomic and industrial experimentation carried out there has high-lighted several species of noteworthy promise for structural and industrial purposes and for erosion control. *Bambusa tulda* and *B. longispiculata,* two closely related species from India, have proved to be outstanding for making furniture and split-bamboo fishing rods, especially heavy-duty salt-water rods.

They are also especially suited for use as structural elements in low-cost houses for tropical conditions. *Bambusa tuldoides,* a Chinese species, is also well suited for these uses, but its wood is not so strong as that of the two already mentioned. (According to unpublished data from tests made by George Merritt, the tensile strength of the wood of the internodes of *B. tuldoides* is about 40,000 pounds to the square inch, whereas according to tests carried out at the College of Agriculture of the University of Puerto Rico, the tensile strength of *B. tulda* is 60,000 pounds to the square inch.) *B. tuldoides* has, however, the advantage of being somewhat more cold-resistant, easier to propagate, and more prolific. All three of these species are suitable for the control of erosion.

Bambusa textilis, a Chinese species, has special promise as material for woven ware, such as basketry and matting, and for durable garden stakes. *Dendrocalamus strictus,* from India, a species with thick-walled, strong culms, has found special use in the bamboo furniture industry in Puerto Rico.

Bambusa vulgaris, probably native to Madagascar, was one of the first bamboos to be introduced into the Western Hemisphere. For that reason, and because of the ease with which it is propagated and its high productivity, it has long been the most common bamboo in cultivation in the American

tropics. It is utilized in many areas in the absence of more suitable species for general farm purposes, including house construction, fences, and shades and pots for nursery plants. The extreme susceptibility of its wood to invasion by powder-post beetles, however, sometimes means severe losses to its users. This species has been used successfully by the Trinidad Paper Pulp Company, which maintains a plantation of more than 800 acres as a source of paper pulp. It is not the best bamboo for paper pulp but it is a heavy producer.

Bambusa multiplex and several of its horticultural forms, all apparently of Chinese origin, are less tender than the other tropical species mentioned and are suitable for landscaping; they have therefore become perhaps the most familiar bamboos of the warmer parts of the United States. They thrive as far north as Savannah on the Atlantic seaboard. The culms of the so-called parent species, which attain a height of 30 feet and a diameter above 1 inch, provide structural elements for low-cost houses in Jamaica. They also make a good paper pulp.

Sinocalamus oldhami (*Dendrocalamus latiflorus* of California gardens), from Formosa, is frequently cultivated as an ornamental in the United States, from San Francisco southward and in the warmer parts of the Gulf States. Its freedom from pests and its stately form give this bamboo a special place in the hearts of many plant lovers. Its culms grow tall and erect and in compact, slowly spreading clumps.

Trials of the hardier group of introduced bamboos have been largely carried out by private growers. The results to date comprise principally data on the adaptation of the various species to the areas where they have been tried, although E. A. McIlhenny, in articles in the National Horticultural Magazine for January and April, 1945, has given valuable information on cultural methods and yields of several species at Avery Island, La.

These hardier bamboos are represented—among the introductions of superior promise—principally by species of *Arundinaria* and *Phyllostachys*. There are a good many introductions of relatively minor importance, except as ornamentals, from other genera, such as *Pseudosasa, Sasa, Semiarundinaria, Shibataea,* and *Sinarundinaria.*

Bamboos of the genus *Sinarundinaria* (rarely seen in this country outside of California) are exceptional in the hardy group in that they have certain structural features characteristic of most tropical bamboos—a caespitose (compact) clump habit, determinate (nonrunning) rhizomes (underground stems), and lack of visible tessellation (cross-veins) in the leaf blades. All of the other hardy bamboos are characterized by tessellate-veined leaf blades (with cross-veins forming little rectangles) and by slender "running" rhizomes that are responsible for their spreading, aggressive growth habit.

Arundinaria amabilis was only recently introduced, at least as living plants, from China. Its industrial importance in this country is a matter of history, however, for since the turn of the century its culms have been the most highly satisfactory and most universally used source of material for split-bamboo fishing rods. Curiously, although our supply of this bamboo comes from China, where it is cultivated and processed for export, it is known in the trade as Tonkin Cane.

Arundinaria simoni, another Chinese species introduced here by way of Europe, has become rather common in cultivation, chiefly as an ornamental. During the recent war, an industrial concern in Florida built up a considerable trade in the culms, using them chiefly as handles for shuffleboard mallets.

Pseudosasa japonica (more popularly called *Arundinaria japonica*), which comes from Japan, where it is known as the arrow bamboo, is perhaps the most widely distributed exotic bamboo in cultivation in the United States. It thrives all the way from Florida to New York City and in corresponding climates westward.

Semiarundinaria fastuosa, introduced early in the century from Japan, where it is known as the Narihiri bamboo, is one of the hardiest; in that respect it approaches *Pseudosasa japonica,* which it rivals in distribution, if not in abundance, in the United States. The plant has an erect habit and good foliage and is considered one of the best of the hardy introduced bamboos for ornamental purposes.

Of the genus *Phyllostachys,* some 30 kinds have been introduced from China and Japan. Of these, the following species and varieties have been established to some extent in general cultivation: *P. aurea, aureosulcata, bambusoides, bambusoides* var. *castilloni, congesta, dulcis, edulis, meyeri, nidularia, nigra, nigra* var. *henonis, nuda, purpurata, sulphurea* var. *viridis, viridiglaucescens,* and *vivax.* The young shoots of all known species of this genus are good to eat, perhaps the most highly esteemed being those of *P. dulcis* and *P. sulphurea* var. *viridis.*

Bamboos of the genus *Phyllostachys* constitute the principal source of paper pulp, and of raw material for hundreds of other industrial needs in China. Several species have become widespread or locally abundant in cultivation in this country.

Phyllostachys bambusoides, one of the so-called Giant Timber Bamboos and perhaps the best known of the group, apparently was introduced first from Japan (where it is known as Madake), and later from China, its native home. At the Barbour Lathrop Plant Introduction Garden and at the old Tevis estate near Bakersfield, Calif., it produces culms 75 feet tall and 6 inches in diameter. These are used in this country chiefly for interior decoration (paneling, for example), merchandising kiosks, split-bamboo fishing rods, staving-off poles, garden fences, shade houses, flag poles, and poles for collecting Spanish-moss. The slender stems of a horticultural form, Slender Crook-stem, are said to make the best poles for harvesting pecans.

Phyllostachys aureosulcata (*P. nevinni* of some of the earlier records), a Chinese species, was extensively distributed some years ago for trial as the stake and forage bamboo. Its culms are used to a considerable extent locally for fishing poles and garden stakes, but aside from its graceful habit and its relative hardiness (it thrives in Washington, D. C., and good examples of it may be seen in the outdoor aviary at the National Zoological Park), it has less to recommend it from a utilitarian point of view than many other species of the genus.

Phyllostachys aurea, also a native of China, produces a high percentage of culms with shortened basal internodes, the character by which it is most readily recognized. This is an excellent bamboo for fishing poles, and important quantities of the culms were imported from Japan for the purpose.

Phyllostachys meyeri, similar to *P. aurea* in size and general appearance but lacking the shortened basal culm internodes, was introduced from China by Frank N. Meyer early in the century. It is good for general farm purposes and for fishing poles.

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